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William B. Davison
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A Comparison of Predation Rates on Real and Artificial Nests of Grassland Birds

(TITLE)

BY

William B. Davison

B.S., University of Montana, 1996

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
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ABSTRACT

I compared rates of predation between real and artificial nests of grassland birds in order to test the impact of nest type, nest position, and egg size on predation rates. I distributed wicker avicultural baskets and realistic grass nests baited with a clay egg and either northern bobwhite (*Colinus virginianus*) or house sparrow (*Passer domesticus*) eggs in four Conservation Reserve Program (CRP) grasslands in east-central Illinois. Nest success averaged 86.5% for 12 days of exposure for artificial nests. For real nests, nest success was markedly lower; averaging 39% over the entire nesting cycle and 59% during approximately 12 days of incubation. Wicker nests were depredated more often than realistic grass artificial nests (18% versus 8%), and nests baited with house sparrow eggs were depredated more often than nests baited with quail eggs (22% versus 9%). Elevated and ground nests were depredated at the same rate. No edge effects were detected for real or artificial nests at road, rowcrop, or wooded edges. Patterns of nest predation on wicker nests were markedly different from depredation patterns on real nests over time and among fields. In contrast, patterns of nest predation on realistic grass artificial nests corresponded much more closely with predation rates of real nests over time and among fields. I suggest that future artificial nest studies use nests and eggs that mimic as closely as possible the real nests and eggs of target species. Use of unrealistic artificial nests and eggs, at least in grasslands, may result in patterns of predation that do not accurately reflect the variation in predation rates over time and locations for real nests.

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INTRODUCTION

Native grassland birds have shown steeper, more consistent, and more geographically widespread population declines than any other ecological group of birds in North America (Askins 1993, Knopf 1994). In the Midwest, 4 of the region's 5 fastest declining species are associated with grasslands (Herkert et al. 1996). Declining grassland bird species occupy diverse habitat types, suggesting that the causes of population declines may be widespread (Herkert et al. 1996). A variety of factors involving complex interactions are believed to be responsible for these declines, including limited winter habitat and resources (Fretwell 1986), agricultural disturbance during nesting (Bollinger et al. 1990, Frawley & Best 1991), altered predator communities (Sargent et al. 1984, Ball et al. 1994, Sovada et al. 1995), and the decline and fragmentation of grassland habitat (Bollinger & Gavin 1992, Herkert 1994). While the relative importance of these factors in causing population declines is unclear, it has been shown that declines in the number of grassland birds in the Midwest are most strongly correlated with a decrease in the acreage of pasture and hayfields in a region (Herkert et al. 1996, Herkert 1997).

In addition to a decrease in agricultural grasslands, native grasslands have declined more than any other major ecosystem in North America (Samson & Knopf 1994). These declines have been particularly severe in the Midwest, where mesic tallgrass prairie, sedge meadows, and lakeplain wet

prairie have all been classified as critically endangered habitats in the United States (Noss et al. 1995). The remnants of native grasslands that remain are often small. In Illinois, less than 20% of the state's prairie remnants are over 10 ha, and less than 4% are over 40 ha (Herkert 1994).

One program that has attempted to reduce this loss and fragmentation of grassland habitat is the Conservation Reserve Program (CRP) of the United States Department of Agriculture. The CRP began in 1985 and resulted in 36.4 million acres of permanent grass cover being set aside. The recently updated CRP has attempted to expand the benefits of the CRP to grassland birds. Among the new CRP provisions in the 1996 Farm Bill is an Environmental Benefits Index, which is used to rank landowner bids. Higher ranks are given to applicants for adopting practices that reduce water and wind erosion of topsoil, provide quality wildlife habitat, provide benefits likely to stay in place beyond the contract period, and for fields located within a state or national conservation priority area (McKenzie 1997).

The prevalence of small, often isolated tracts of grassland in an inhospitable matrix of rowcrops and forest may result in many areas having grassland bird nest success that is below levels necessary for population maintenance. This is due in large part to negative edge effects associated with small tracts of habitat (Gates & Gysel 1978, Johnson & Temple 1990). Decreased reproductive success of birds breeding in fragmented landscapes has been well documented for forest birds (Robinson et al. 1995), and a few studies have documented this in grassland birds as well (Samson 1980,

Johnson & Temple 1986, 1990, Burger et al. 1994). Factors associated with lowered reproductive success include increased rates of brown-headed cowbird (*Molothrus ater*) parasitism in grasslands fragmented by trees and shrubs (Johnson & Temple 1986, 1990, J. Herkert pers. comm.) and increased rates of predation associated with human-subsidized predators, such as cats (*Felis catus*), raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), opossums (*Didelphis marsupialis*), and red foxes (*Vulpes fulva*) (Sargent et al. 1984, Warner 1985, Vickery et al. 1992, Ball et al. 1994).

Nest predation is typically the primary cause of nesting mortality for open-nesting passerines (Nice 1957, Ricklefs 1969, Martin 1993). This includes grassland birds, many of which experience high rates of reproductive failure due to nest predation (Best 1978, Wray & Whitmore 1979, Wray et al. 1982, Baines 1990, Johnson & Temple 1990, Martin 1993, With 1994). Predation rates may be influenced by a variety of factors, including nest location (Martin 1993, With 1994), nest density (Martin 1988, Esler & Grand 1993), defense by adults (Goransson et al. 1975), distribution (clumped, dispersed) (Picman 1988), nest type (open, cavity) (Martin 1993), and degree of concealment (Sullivan & Dinsmore 1990). In addition, the type of predator (bird, reptile, mammal) can affect reproductive success rates (Martin 1987, Storaas 1988, Willebrand & Marcstrom 1988, Clark & Nudds 1991, Miller & Knight 1993).

One of the most widely used means of assessing the impact of different variables on rates of predation has been artificial nest studies (Major & Kendall 1996). The experimental utility of artificial nests allows for controlled

experiments, which can assess the impact of many variables. However, the majority of artificial nest studies have been done on waterfowl and forest birds. Only 5 studies have used artificial nests to study predation on grassland songbirds (Kulesza 1980, Mankin & Warner 1992, Burger et al. 1994, Hughes 1996, Bergin et al. 1997). Of these, only Hughes (1996) provided comparative data on real nests of grassland birds.

Despite the widespread use of artificial nest experiments to study nest predation, the reliability of this technique is still in question (Clark & Nudds 1991, Paton 1994). This is due in part to the lack of realism between experimental setups (i.e. nest type and egg size) and the natural systems they attempt to model (Major & Kendal 1996). Even if consistent patterns were evident, the usefulness of studies on waterfowl and forest songbirds are of limited use for comparisons with grassland birds due to differences in habitat, the surrounding landscape, and the predator community (Nour et al. 1993).

Artificial nests are often designed to test predation rates on avian communities (Wilcove 1985, Picman 1988, Langen et al. 1991, Yahner & Morrel 1991, Bayne & Hobson 1997). Consequently, artificial nests seldom resemble the natural nests they are attempting to mimic. In addition, most artificial nest studies do not provide comparative data regarding predation on natural nests, and those that do have produced conflicting results (Major & Kendall 1996). There are several possible, yet largely untested, explanations for this lack of consensus. Predator species are rarely documented, even though several studies have shown that different predators prey upon

artificial versus natural nests (Willebrand & Marcstrom 1988, MacIvor et al. 1990). However, the realism of artificial nests has been shown to affect predation rates.

Martin (1987) used 3 types of artificial nests — wicker nests, wicker nests covered with moss, and old Hermit thrush (*Catharus guttatus auduboni*) nests placed in trees and on the ground — to discern differences in predation rates. The more realistic artificial nests suffered increased predation in trees, compared to the unrealistic wicker nests; however, both realistic and unrealistic artificial nests suffered the same predation rates when placed on the ground. This suggests that different predators (i.e. visually versus scent-oriented) may specialize on nest types and highlights the need for predator identification.

The size of the eggs used in a study can also affect predation rates by reducing the impact of some small predators that are unable to break the larger eggs (Picman 1988, Roper 1992, Haskell 1995a, DeGraaf & Maier 1996). Eighty-two percent of 67 artificial nest studies reviewed by Major and Kendall (1996) used either quail or chicken eggs, both of which are much larger and have thicker shells than the small passerine eggs they are usually attempting to mimic.

Rates of predation are also influenced by the degree of nest concealment. Yet, few studies detail artificial and natural nest locations (Major & Kendall 1996). Controversy also exists over the relative importance of human visitation and subsequent scent trails left at visited nests (Major

1990). It is likely that the effect of human interference varies with the species studied, the type of habitat, and the predators present. For instance, it is believed that snakes do not respond to clues left by humans (Gottfried & Thompson 1978). In contrast, olfactory-searching predators, such as raccoons, have been shown to depredate more nests that smell of human scent compared to nests that smell of deer scent (Whelan et al. 1994). The use of nest markers has been shown to both increase predation rates (Yahner & Wright 1985) and to have no effect (Nilsson et al. 1985). Differences probably arise due to differences in predators and distance of the markers from the nests.

Until the relative importance of these confounding factors has been determined, the results of artificial nest studies should be interpreted with caution. Many artificial nest studies acknowledge that absolute rates of predation on artificial nests may not be the same as predation rates on real nests, but argue that artificial nests should represent the relative rates or patterns of predation between different treatments, such as habitat type, patch size, or time period (Sullivan & Dinsmore 1990, Seitz & Zegers 1993, Bayne et al. 1997). This assumption is commonly accepted despite several studies that show a lack of correlation between relative predation rates on real and artificial nests (Kulesza 1980, George 1987, Salonen & Pentinen 1988, Storaas 1988, Willebrand & Marcstrom 1988, MacIvor et al. 1990, Reitsma et al. 1990, Roper 1992). Given the ubiquity of artificial nest studies and their impact on

ecological theory and, consequently, conservation actions, it is important that their assumptions continue to be critically examined.

The objectives of this study were to: 1) compare both absolute and relative predation rates between natural nests and realistic and unrealistic artificial nests; 2) assess the impact of edge effects at varying distances from rowcrop, road, and wooded edges; 3) compare predation rates between both artificial and natural, domed ground-nests and elevated, open-cup nests; and 4) assess the impact of egg size on rates of predation.

METHODS

Study site

My research was conducted in Coles and Cumberland counties in east-central Illinois, where the topography is primarily flat on the uplands and gently rolling along drainageways. The soils are moderately well-drained (Xenia-Fincastle-Toronto Association), silty soils formed of loess and glacial till (Illinois Agricultural Experiment Station 1993). Approximately 70% of the land is used to grow corn and soybeans. The average daily maximum temperature is 29°C. The average annual precipitation is 94 cm, of which 60% falls from April through September (Illinois Agricultural Experiment Station 1993).

Six CRP fields were selected for study in the fall of 1996. The fields ranged in size from 13 ha to 29 ha (mean = 24 ha) and were planted to redtop (*Agrostis alba*) and/or orchard grass (*Dactylis glomerata*) in 1989, 1992, or 1993. Three 12-day, artificial nest trials were conducted between 25 May and

13 July 1997. A 12-day exposure period was selected because this is a typical incubation period for many grassland passerines (Ehrlich et al. 1988). Fourteen artificial nests were placed in each of the 6 fields for each trial. Trial 1 ran from 25 May to 6 June; trial 2 ran from 11 June to 23 June; and trial 3 from 1 July to 13 July. One orchard grass field was later dropped from the study due to a lack of nesting activity. The real and artificial nests from 2 redtop fields that were connected by a grassed waterway and an unmowed section of Kentucky bluegrass (*Poa pratensis*) were lumped together into 1 field in order to increase sample sizes of natural nests. This resulted in 210 artificial nests being set out in 4 CRP fields.

Half of the artificial nests consisted of nests constructed by weaving dried grass into a wire frame (see Kulesza 1980, Sieving 1992) (12 cm outside diameter, 6 cm high, and 4.5 cm deep) that approximated the dimensions and appearance of a dickcissel (*Spiza americana*) nest. The other half of the artificial nests consisted of wicker avicultural baskets of the type used in previous artificial nests studies (Wilcove 1985, Burger et al. 1994). Dimensions of the wicker nests were 10 cm wide and 5 cm deep. All nests were exposed to the weather for one week prior to being set out in the CRP fields.

Nest sites for each trial were randomly selected by using existing avian survey transects located 100m apart and parallel to the longest axis of the field. The placement of each nest was determined by selecting 3 random numbers. The first number indicated the distance along the transect, the second number

indicated the right-angle distance from the transect, and the third number indicated the side of the transect. Wicker and grass nests were alternatively placed on the ground hidden in leaves of grass (to imitate meadowlark nests) or in an elevated position 20-50 cm above the ground in a suitable forb or clump of grass (to imitate dickcissel nests). Nest location was marked by placing flagging tape 5m to the north of the nest.

One northern bobwhite (*Colinus virginianus*) or 1 house sparrow (*Passer domesticus*) egg was alternatively placed in artificial nests. Each nest also held one clay egg. This resulted in a nearly equal number of combinations of nest positions and egg types for wicker and grass nests. Different sizes of eggs were used to assess the impact of small predators, such as rodents, that may not be able to break the shells of the larger quail eggs (Reitsma et al. 1990, Roper 1992, Haskell 1995a, DeGraaf & Maier 1996). Clay eggs were used to facilitate predator identification (Major 1991, Bayne & Hobson 1997, Rogers et al. 1997). Rubber gloves were worn when distributing artificial nests to reduce human scent.

Artificial nests were checked after 6 and 12 days of exposure to determine their fate. Nests were considered depredated if either the sparrow or quail egg was damaged or missing. If just the clay egg was chewed on by rodents, that nest was not counted as depredated. The distance of an artificial nest to rowcrop, road, and wooded edges was determined by pacing off the distance at the time of nest placement.

Vegetation measurements

Characteristics of vegetation at natural nest sites were collected after the end of a nesting attempt to determine the vegetation traits affecting bird species breeding in CRP fields. Vertical cover of the vegetation was assessed by placing a Robel pole next to the nest and taking a reading from 4m south of the Robel pole and 1 m above the ground (Robel et al. 1970). The lowest height above the ground at which the pole became visible was recorded. The height of vegetation supporting the nest was also measured. Percent canopy cover of forbs, grasses, litter, bare ground, woody, and total cover were estimated within a 0.25 m^2 frame centered on the nest. Vegetation cover was estimated on an overlapping basis, so that the sum at a given sample point could exceed 100%. Plant species that occupied 2% or more of the quadrat were recorded separately. Coefficients of variation for vegetation height and total cover were used to index vertical and horizontal vegetation patchiness (Rotenberry & Wiens 1980).

Natural nest success

The nest success of natural nests was determined by locating and monitoring nests in each CRP field. Teams of 3-4 people would search for and monitor nests in each field following the guidelines of Martin and Geupel (1993). I calculated the daily survival rates (DSR) of nests and Mayfield nest success rates (Mayfield 1961,1975). All nests were marked with

flagging tape placed 5m to the north. The outcome of each nest attempt was assessed using the techniques of Best and Stauffer (1980). Nest failure was attributed to weather when nests were abandoned after a severe storm. Nests were considered abandoned from unknown causes when nest contents remained unchanged and adults were not present during two successive visits. Nest failure was attributed to brown-headed cowbird parasitism when nests were abandoned after cowbird egg(s) were deposited, when only cowbird eggs remained in the nest, or when only cowbird young fledged.

Statistical analyses

The daily survival rates between real and artificial nests were calculated using the methods of Johnson (1979). A multi-factor contingency analysis in the Categorical Model procedure (CATMOD) in SAS was used to determine if predation rates on realistic and wicker artificial nests corresponded with predation rates on real nests between fields and over time (SAS Institute Inc. 1994). T-tests were used to determine vegetation characteristics that differed between depredated and successful (i.e., fledged ≥ 1 young) natural nests. The effects of distance to road, rowcrop, and wooded edges on predation rates were analyzed using chi-square tests. The level of significance for all tests was set at $P \leq 0.05$.

RESULTS

Of the 210 artificial nests set out in CRP fields, 4 could not be relocated. Twenty-seven of the remaining 206 artificial nests were depredated, resulting in a Mayfield nest success of 86.5% and a Mayfield daily survival rate of 98.8%.

Two hundred eighty-three real nests of 6 species had a Mayfield nest success of 38.5% and a Mayfield daily survival rate of 95.1% (Table 1). The Mayfield daily survival rate between artificial and real nests was significantly different (P<.001). Wicker artificial nests were depredated more often (18%) than were realistic grass artificial nests (8%)($\chi^2 = 5.9, 1df, P = .02$;Table2). Nests baited with quail eggs were depredated less than nests baited with house sparrow eggs ($\chi^2 = 4.6, 1df, P = .03$). Rates of predation on ground and elevated nests were not different ($\chi^2 = .04, 1df, P = .84$). Patterns of nest predation on wicker nests were different from patterns of nest predation on real nests over time ($\chi^2 = 5.9, 1df, P = .05$; Fig. 1) and among fields ($\chi^2 = 10.0, 1df, P = .02$; Fig 1). However, patterns of nest predation on realistic artificial nests did correspond closely with patterns of predation on real nests over time ($\chi^2 = 0.3, 1df, P = .87$; Fig. 2) and among fields ($\chi^2 = 1.6, 1df, P = .65$; Fig. 2).

Clay eggs showed signs of predation in 80 of 206 artificial nests; however, only 27 of these 80 nests actually had the quail or house sparrow eggs depredated. There was no relationship between the clay egg being chewed on and the fate of the real egg when nests with quail eggs and nests with house sparrow eggs were combined ($\chi^2 = .33, 1df, P = .56$) or when nests were separated into nests with house sparrow eggs ($\chi^2 = .001, 1df, P = .98$) and nests with quail eggs ($\chi^2 = 1.0, 1df, P = .31$). Fifty-four of the 206 clay eggs showed teeth marks of small rodents. Of the 27 nests that had the real egg depredated, 7 clay eggs had been removed from the nest and could not be relocated. Nine clay eggs showed signs of small rodent predation, 7 showed

signs of bird predation, and 4 showed signs of large mammal predation. There was no relationship between type of predator and nest type ($\chi^2 = .64, 2df, P = .73$) or predator type and nest position ($\chi^2 = .94, 2df, P = .63$).

Despite the use of clay eggs, identification of predators remained uncertain. Eighty-eight percent of depredated artificial nests had the house sparrow or quail egg removed without any noticeable sign left at the nest. Similarly, 90% of real nests were depredated with little or no evidence of the predator left at the nest. Signs from clay eggs suggest that small rodents were the principle predator at artificial nests, whereas our observations of depredated nests with no signs of predation suggest that snakes were the primary predator of real nests.

Artificial nests did not experience increased rates of predation near (less than 50m) wooded ($\chi^2 = 0.4, 1df, P = .55$), road ($\chi^2 = 0.0, 1df, P = .99$), or rowcrop edges ($\chi^2 = .61, 1df, P = .43$; Table 3). Real nests also did not experience increased rates of predation near wooded ($\chi^2 = 1.5, 2df, P = .47$), road ($\chi^2 = 0.6, 2df, P = .74$), or rowcrop edges ($\chi^2 = 4.7, 2df, P = .09$; Table 3).

For 110 real ground nests, 6 vegetation measurements were significantly different between depredated and fledged nests (Table 4). Ground nests that fledged young were generally more concealed than ground nests that were depredated. Depredated nests had lower values for vegetation height, Robel density, percent forb cover, percent live vegetation, and percent side cover. None of the vegetation variables differed significantly for depredated and successful elevated nests (Table 5).

DISCUSSION

Predation rates on artificial nests were significantly lower than predation rates on real nests in our study. This is the same pattern found in Kansas CRP fields by Hughes (1996), which is the only other study that has compared nest success between real and artificial nests of grassland birds. The rate of predation on wicker nests (18%) more closely approximated the rate of predation on real nests (50% over the entire nesting cycle and 34% over the incubation period) compared to the 8% rate of predation on grass nests. Most studies acknowledge that comparisons of the absolute rate of predation between real and artificial nests are not always valid, however, most studies do assume that artificial nests accurately represent the relative rate or pattern of predation on real nests over time or among different types of habitat (Sullivan & Dinsmore 1990, Seitz & Zegers 1993, Bayne et al. 1997). Despite more closely approximating the absolute rate of predation on real nests, patterns of predation over time and among fields for wicker nests did not correspond with the patterns of predation on real nests over time and among fields. In fact, their pattern was nearly opposite that found for natural nests. In contrast, rates of predation on grass nests corresponded much more closely with rates of predation on real nests both over time and among fields. This suggests that in grasslands, the realism of artificial nests is important for ensuring that patterns of predation on artificial nests accurately reflect the patterns of predation on real nests.

There are several possible reasons why the realism of the artificial setup (both nest type and egg type) could be important for ensuring relevant results from artificial nest studies. Visually-oriented predators, such as birds, may more easily locate wicker nests than real nests (George 1987, Storaas 1988, Willebrand & Marcstrom 1988, Sullivan & Dinsmore 1990). The realism of eggs used in artificial nests may be important if small predators, such as mice and shrews, are present (Maxson & Oring 1978, Guillory 1987, Reitsma et al. 1990, Roper 1992, Leimgruber et al. 1994, Haskell 1995a, DeGraaf & Maier 1996). The use of eggs larger than eggs of the target species may preclude predation by small predators (Roper 1992, Haskell 1995a, DeGraaf & Maier 1996). This appears to have happened in our study, as small rodents chewed on 39% of all clay eggs and nests baited with quail eggs were depredated less often than nests baited with house sparrow eggs. The lack of parental activity at artificial nests may dramatically reduce a predator's ability to locate the nest, while at the same time allowing small predators, such as rodents, to eat eggs without being attacked by 1 or both parents. Also, cues given by parents, including movement, sounds, and scent, may increase predation by mammals (Vickery et al. 1992), birds (Storaas 1988, Willebrand & Marcstrom 1988, MacIver et al. 1990), and some snakes (Goodman & Goodman 1976, Hoi & Winkler 1994).

The importance of snakes as predators of bird nests in grasslands and shrub habitats has been well documented (Fitch 1963, Best 1974, 1978, Goodman & Goodman 1976, Joern & Jackson 1983, Wheeler 1984). Based

upon my observations in the field, snakes appeared to be the dominant predator of real nests. Prairie kingsnakes (*Lampropeltis calligaster*), common garter snakes (*Thamnophis sirtalis*), black ratsnakes (*Elaphe o. obsoleta*), and blue racers (*Coluber constricter*) were all commonly observed on our study sites. I monitored over 20 nests where young or eggs would disappear 1 or 2 at a time over a several day period. The disappearance of single eggs over multiple days was observed at a mockingbird nest, where a Texas ratsnake (*Elaphe obsoleta lindheimeri*) consumed the incubating female (Joern & Jackson 1983). I observed two incidents of snake predation: one in which a prairie kingsnake ate grasshopper sparrow nestlings, and another where a common garter snake ate field sparrow nestlings. The prairie kingsnake had a 1-2 day old grasshopper sparrow nestling in its mouth when it was discovered at the nest. Upon being disturbed, the snake dropped the nestling and disappeared. I monitored that nest over the next 3 days, and 1 nestling disappeared every day for 4 days until the nest was empty.

Given that snakes are often important predators of bird nests in grassland and shrub habitats, understanding their role as predators of artificial nests will lead to more accurate assessments of predation pressures on real nests. There are several reasons to question the ability of artificial nests to accurately represent snake predation. Marini and Melo (in press) have shown that 22 species of snakes known to eat bird eggs in the wild showed no response to room temperature quail eggs presented to them in captivity, and an additional 9 species showed no response to eggs pre-heated to the normal

incubation temperature of birds. In addition, snakes have never been documented (i.e. photographed) depredating artificial nests, despite the proliferation of artificial nest studies using remote cameras to monitor predators (Marini & Melo in press).

The cues used by snakes to locate and capture their prey provide some insight into why snakes may be underrepresented in artificial nest studies. Some snakes have been shown to use the intensity of parental mobbing behavior to help them locate nests (Goodman & Goodman 1976). A combination of visual and chemical stimuli may be required to elicit a response from some snakes. Visual cues have been shown to be important for snake foraging (Czaplicki & Porter 1974, Drummond 1979), however, in the absence of chemical cues it has been shown that visual stimuli from live prey do not elicit attack by newborn garter snakes (Burghardt 1966). Given the widespread occurrence of snakes and the fact that they have never been documented eating eggs in an artificial nest, it seems likely that the cold, relatively scent free, unattended eggs in artificial nests do not stimulate snakes to eat them.

Most ecological theory developed from artificial nest studies has been derived from studies of forest habitats, where artificial nests are often depredated at a higher rate than real nests (Salonen & Pentinen 1988, MacIvor et al. 1990, Reitsma 1992, Roper 1992). In contrast, predation rates on artificial nests in grassland habitats are often lower than rates of predation on real nests (Kulesza 1980, Hughes 1996, Bergin et al. 1997). This is likely due in part

to snakes not eating eggs in artificial nests. Kulesza (1980) placed artificial nests in grassland, shrubland, and wooded habitats in 3 separate locations in east-central Illinois and found that for each location grasslands had the lowest predation rate, followed by shrublands and then wooded habitat. This trend corresponds with the diversity of predators and consequently the presence of mammals and birds in the different habitats. As the vertical structure of the vegetation increased from the grasslands to the woodlands, the number of possible predator species increased as well. While predator species were not systematically surveyed, his observations indicate that snakes were most numerous in the grasslands and shrublands and mammals and birds were most numerous in the woodlands.

Rates of predation on both real and artificial nests did not increase near wooded, road, or rowcrop edges in this study. Mankin and Warner (1992) and Hughes (1996) also found no edge effect, however, Johnson and Temple (1986), Møller (1989), and Burger et al. (1994) did find that predation rates increased near woody edges. The apparently contradictory results of these and other nest predation studies highlight the need for large-scale studies that attempt to explain why edge effects occur in some areas and not in others. Research on edge effects in forested landscapes has indicated that rates of nest predation on real and artificial nests varies due to differences in landscape-scale forest cover (Robinson et al. 1995, Donovan et al. 1997). The percentage of landscape-scale grass cover may similarly affect predation rates on grassland bird nests and the presence or absence of edge effects.

The lack of edge effects in some grasslands may be driven by decreased nest densities near edges. Some species of grassland birds are more likely to nest further (>45m) from wooded edges than nearer to them (Johnson & Temple 1986). Grasshopper sparrows and bobolinks have been shown to be less common within 50m of an edge (Delisle 1995, Helzer 1996). The combined impact of decreased nest densities near edges and the fact that, at least in our study sites, the primary predators (snakes) appeared to be equally as abundant in interior and edge locations may help explain the lack of edge effects in some grassland habitats.

The fate of real ground nests (bobolink, eastern meadowlark, and grasshopper sparrow) was significantly affected by 6 of the 10 vegetation variables we measured. Ground nests that fledged young had taller, more dense vegetation around the nest with more forb, live vegetation, and side cover than depredated nests. This could reflect the rate at which visually oriented predators locate nests (Jones & Hungerford 1972, Sugden & Beyersbergen 1986, Storaas 1988), or it could indicate that scent-oriented predators preferred to search for nests in less dense cover. The fate of real elevated nests (field sparrow, redwing blackbird, dickcissel) was not significantly affected by any of the 10 vegetation variables. This may be due to the fact that over half of the elevated nests were red-winged blackbird nests, which are relatively large conspicuous nests that had a higher predation rate (67%) than any other species in this study.

I found that patterns of predation on artificial nests did not correspond with predation rates on real nests (Kulesza 1980, Salonen & Pentinen 1988, Storaas 1988, Willebrand & Marcstrom 1988, MacIvor et al. 1990, Reitsma 1992, Roper 1992), however, this applied only to our wicker artificial nests. The percent of wicker artificial nests that were depredated increased over time, whereas the percent of depredated real nests decreased. Patterns of predation on my grass artificial nests did accurately reflect patterns of predation on real nests, but I did not confirm that the same species of predator were depredating real and grass nests. A correlation between rates of predation on real and grass nests could reflect the general activity pattern of the entire predator community. This seems to be a more likely explanation, given that snakes appeared to be the major predator of real nests, yet have never been documented depredating an artificial nest.

My results indicate that the relative rate of predation on wicker artificial nests does not necessarily represent the relative rate of predation on real nests. Future studies should attempt to identify predators of real and artificial nests and use artificial setups that match as closely as possible the nests and eggs of target species in order to reduce some of the biases associated with wicker nests and quail eggs. Use of artificial nests in grasslands may never be a good idea unless artificial nests can be designed to "attract" snakes as predators.

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Table 1. Number of active nests, Mayfield success rate, and daily survival rate of 6 of the most common nesting species in 4 Conservation Reserve Program fields in east-central Illinois in 1997.

Species [a]	No. nests	Mayfield success rate (%)	Daily survival rate (%)
Bobolink	20	62.0 (173) [b]	98.3 (.0031) [c]
Dickcissel	36	43.0 (467.5)	96.4 (.0087)
Eastern meadowlark	81	32.0 (974.5)	96.0 (.0020)
Field sparrow	36	39.0 (333.3)	95.5 (.011)
Grasshopper sparrow	27	35.0 (212)	95.3 (.015)
Red-winged blackbird	83	20.0 (845)	89.0 (.0086)
Total	283	38.5 (3005.3)	95.1 (.0039)

[a] Species with < 5 nests in CRP fields were song sparrow (*Melospiza melodia*), bobwhite quail (*Colinus virginiana*), mallard (*Anas platyrhynchos*), common yellowthroat (*Geothlypis trichas*), savannah sparrow (*Passerchulus sandwichensis*), American goldfinch (*Carduelis tristis*), mourning dove (*Zenaida macroura*), rufous-sided *towhee (Pipilo erythrophthalmus*), and sedge wren (*Cistothorus platensis*).

[b] Nest exposure days in parentheses

[c] Standard errors in parentheses

Table 2. Mayfield success rate and daily survival rate for different artificial nest categories.

Artificial nest category	No. nests	Mayfield success rate (%)	Daily survival rate (%)
Wicker	102	.82 (1386)[a]	98.4 (.0041)[b]
Grass	108	.89 (1488)	99.5 (.0025)
Elevated	109	.89 (1068)	99.0 (.031)
Ground	101	.85 (900)	98.7 (.048)
House sparrow	101	.83 (1335)	98.5 (.005)
Quail	109	92 (1452)	99.3 (.0091)
Wicker with quail	48	.90 (636)	99.1 (.0062)
Wicker with house sparrow	54	.78 (708)	98.0 (.0026)
Grass with quail	61	.94 (816)	99.5 (.012)
Grass with house sparrow	47	.88 (627)	98.9 (.0074)
Total	210	86.5 (2874)	98.9 (.014)

[a] Nest exposure days in parentheses

[b] Standard errors in parentheses

Table 3. Percentage of real and artificial nests depredated at edge (< 50 m) and interior (> 50 m) locations for 3 different types of edge in Conservation Reserve Program fields in east-central Illinois in 1997. [a]

	wooded edge		road edge		rowcrop edge		no. of nests		Overall average	
Nest type	edge	interior	edge	interior	edge	interior	edge	interior	edge	interior
Real	41	49.4	53.6	52.1	66.7	48.3	35	260	53.8±10.5	50±1.6
Artificial	4	11	14.8	14.7	7.1	14.7	76	130	9.8±4.5	13.5±1.7

[a] Overall average is reported as mean ± 1 SD.

Table 4. Treatment means ± SE and P-values from t-tests for vegetation variables measured at real ground nests (n=110) in CRP fields between 6 May and 10 July 1997 in Coles and Cumberland counties, Illinois.

	Treatment mean ± SE		
Vegetation variables	**Depredated Nests**	**Fledged Nests**	**P-value**
Vegetation height (cm)	59.6 ± 2.8	72.0 ± 2.7	<0.01
Robel density (cm)	33.6 ± 1.7	42.0 ± 2.1	<0.01
Litter depth (cm)	6.8 ± 0.5	6.7 ± 0.5	0.94
Forb cover (%)	12.1 ± 2.8	23.9 ± 3.9	0.02
Grass cover (%)	65.7 ± 3.3	63.7 ± 3.5	0.70
Bare ground (%)	3.7 ± 0.8	2.6 ± 0.5	0.23
Live vegetation (%)	72.9 ± 2.9	84.8 ± 2.3	<0.01
Dead vegetation (%)	19.7 ± 3.4	8.2 ± 1.7	<0.01
Total canopy cover (%)	92.9 ± 1.9	93.0 ± 2.0	0.97
Side cover (%)	92.9 ± 1.8	97.1 ± 0.8	0.02

Table 5. Treatment means ± SE and P-values from t-tests for vegetation variables measured at real elevated nests (n=119) in CRP fields between 17 May and 10 July 1997 in Coles and Cumberland counties, Illinois.

	Treatment mean ± SE		
Vegetation variables	**Depredated Nests**	**Fledged Nests**	**P-value**
Vegetation height (cm)	71.4 ± 3.5	74.8 ± 5.0	0.56
Robel density (cm)	40.3 ± 2.3	40.1 ± 2.6	0.97
Litter depth (cm)	5.1 ± 0.5	7.3 ± 1.4	0.10
Forb cover (%)	46.4 ± 4.4	38.2 ± 5.1	0.22
Grass cover (%)	32.4 ± 3.6	39.2 ± 4.4	0.23
Bare ground (%)	2.5 ± 0.6	2.5 ± 0.5	0.93
Live vegetation (%)	86.8 ± 1.6	81.1 ± 2.7	0.06
Dead vegetation (%)	8.3 ± 1.6	10.7 ± 2.5	0.40
Total canopy cover (%)	94.9 ± 1.2	94.3 ± 2.4	0.80
Side cover (%)	90.3 ± 2.6	91.7 ± 3.1	0.72

APPENDIX 1. Mean bird abundance (number of birds/100 ha) for species nesting in CRP fields in Coles and Cumberland counties in east-central Illinois in 1997.[a]

Species	CRP FIELDS					
	Walter's N	Walter's S	King	Harrier	Total	
	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$	SE
Sedge wren (*Cistothorus platensis*)	3.4	0.0	0.0	16	5.25	---
Common yellowthroat (*Geothlypis trichas*)	0.0	0.0	7.1	0	3	---
Dickcissel (*Spiza americana*)	79.3	69.2	82.1	88	80.8	0.78
Rufous-sided towhee (*Pipilo erythrophthalmus*)	0.0	0.0	7.1	0	3	---
Field sparrow (*Spizella pusilla*)	0.0	0.0	117.9	0	47.1	---
Savannah sparrow (*Passerculus sandwichensis*)	24.1	15.4	0.0	0	13	1.39
Grasshopper sparrow (*Ammodramus savannarum*)	31.0	61.5	50.0	8	34.7	0.85
Henslow's sparrow (*Ammodramus henslowii*)	6.9	0.0	10.7	0	7	---
Song sparrow (*Melospiza melodia*)	0.0	0.0	10.7	0	4.2	---
Bobolink (*Dolichonyx oryzivorus*)	106.9	123.1	7.1	8	53.6	1.94
Eastern meadowlark (*Sturnella magna*)	70.0	61.5	107.1	44	72.5	1.19
Red-winged blackbird (*Agelaius phoeniceus*)	244.8	230.8	85.7	324	216.3	1.99
American goldfinch (*Carduelis tristis*)	0.0	0.0	14.3N	0	6	---

[a] Line transects were used to estimate bird abundance. The first transect was placed parallel to the long axis of the field 50 m from the edge. Subsequent transects were placed 100 m apart until the entire field had been covered. Fields were censused once on either 3, 4, or 5 June 1997. Counts were completed between 0630 and 0900 on mornings with no precipitation and wind speeds below 20 km/h. Transects were walked at a slow pace, with frequent stops used to record bird numbers on a field data sheet. All birds seen or heard within 50 m on either side of a transect were counted. I assumed that I saw all birds. Males and females were combined. Mean bird abundance was reported as the number of birds/100 ha.

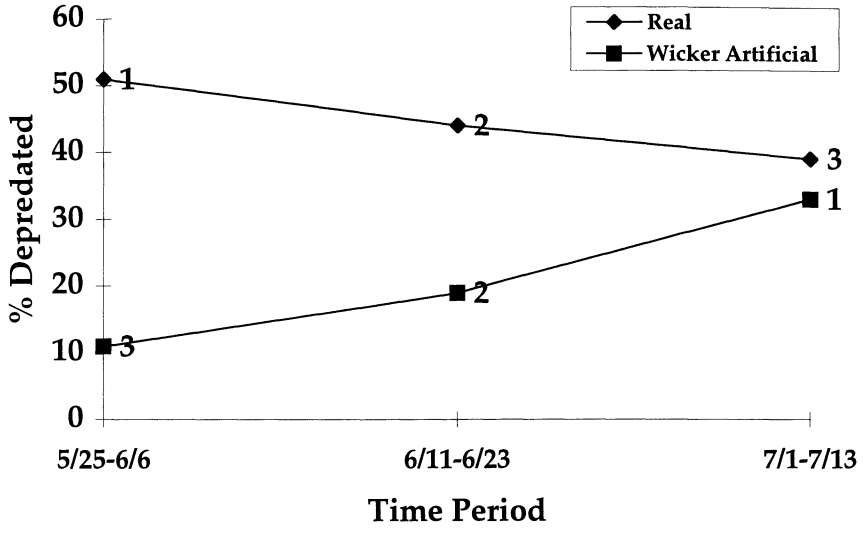
APPENDIX 2. Field means ± SE for vegetation variables measured in 4 CRP fields on 10 June 1997 in Coles and Cumberland counties, Illinois.[a]

	FIELD MEAN ± SE			
Vegetation variables	**King**	**Walter's North**	**Walter's South**	**Harrier**
Vegetation height (cm)	52 ± 3	141 ± 1	69 ± 6	83 ± 6
Robel density (cm)	24 ± 3	45 ± 2	40 ± 5	37 ± 4
Litter depth (cm)	5 ± 1	5 ± 0.4	6 ± 0.9	4 ± 0.5
Forb cover (%)	49 ± 11	6± 1	35 ± 7	62 ± 9
Grass cover (%)	50 ± 8	89 ± 2	53 ± 7	24 ± 8
Total canopy cover (%)	59 ± 8	92 ± 1	81 ± 3	89 ± 5

[a] Characteristics of vegetation in 4 CRP fields were collected on 10 June 1997. Sampling locations were determined by by using a random number table (see methods for artificial nest placement) to generate the locations along an existing avian survey transect. Fifteen samples were taken in each

field. Vertical cover of the vegetation was assessed by placing a Robel pole next to the nest and taking a reading from 4m south of the Robel pole and 1 m above the ground. The lowest height above the ground at which the pole became visible was recorded. The height of vegetation supporting the nest was also measured. Percent canopy cover of forbs, grasses, litter, bare ground, woody, and total cover were estimated within a 0.25-m^2 frame. Vegetation cover was estimated on an overlapping basis, so that the sum at a given sample point could exceed 100%.

A



B

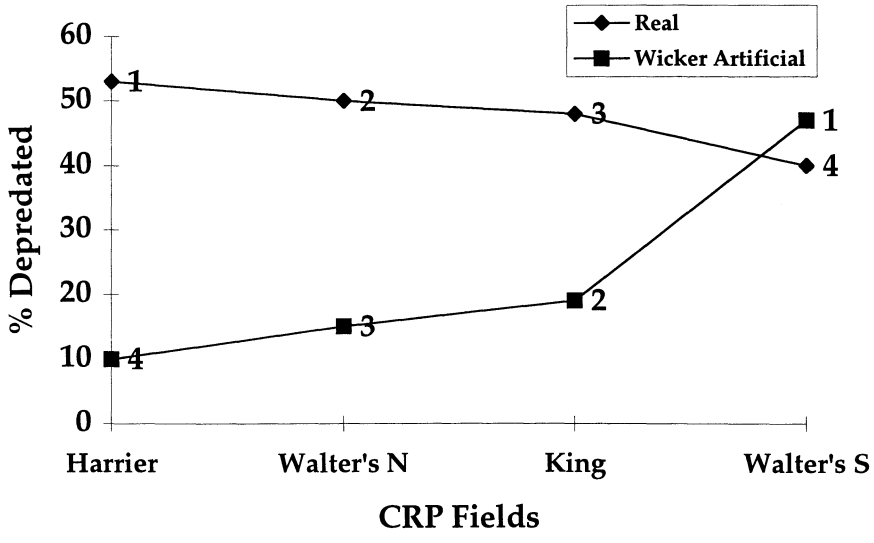
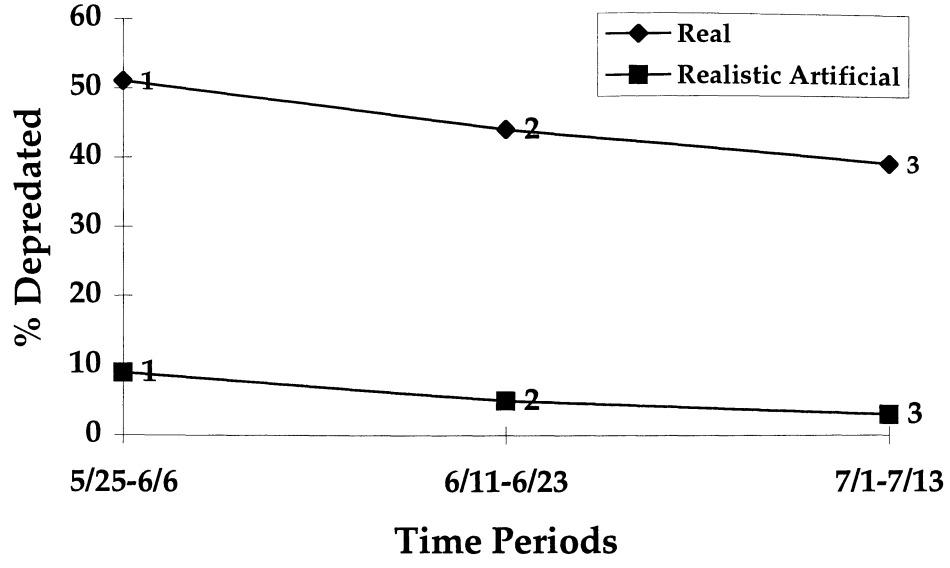


Figure 1. Percent of real nests and artificial wicker nests depredated in CRP fields in east-central Illinois. A shows 3 time periods. B shows 4 CRP fields. Numbers within chart represent ranks.

A



B

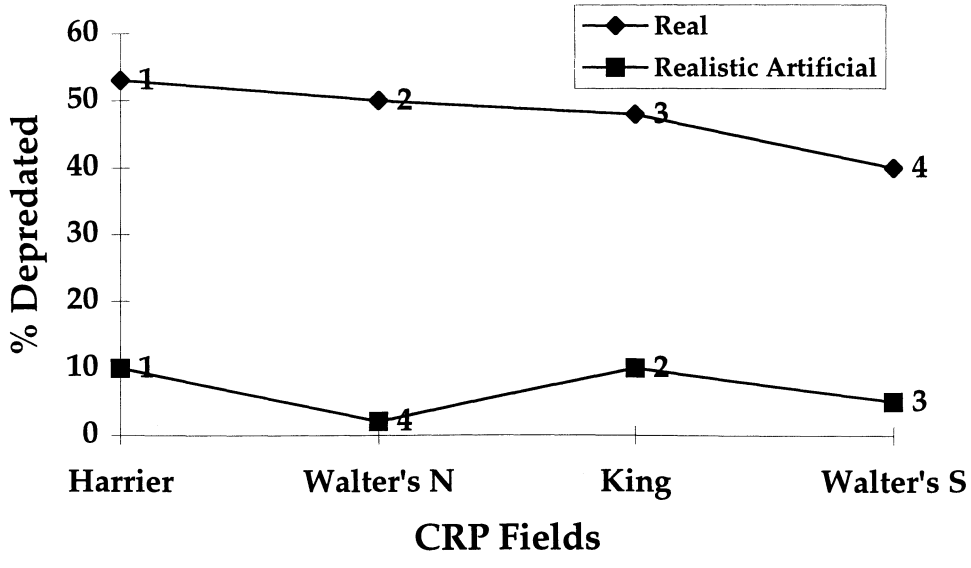


Figure 2. Percent of real nests and realistic artificial nests depredated in CRP fields in east-central Illinois. A shows 3 time periods. B shows 4 CRP fields. Numbers within the chart represent ranks.